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AUTO-SHAPING OF THE PIGEON'S KEY-PECK[1]

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Reliable acquistion of the pigeon's key-peck response resulted from repeated unconditional (response-independent) presentations of food after the response key was illuminated momentarily. Comparison groups showed that acquisition was dependent upon light—food pairings, in that order.

In the usual arrangement for discriminative operant conditioning, reinforcement is conditional on a stimulus and on a response. Food may be delivered to a hungry pigeon only when it pecks a key and only when the key is lighted. By relaxing, in different ways, the conditionality in the rule for delivering food, three other conditioning arrangements of interest can be generated. The delivery of food may be entirely unconditional, *i.e.*, without regard to the stimulus that is present or to behavior; the delivery of food may be conditional on behavior (e.g., the pigeon must peck a key) but unconditional with respect to stimuli; or the delivery of food may be conditional on the stimulus (*e.g.*, food is delivered only when the key is lighted) but unconditional with respect to responses. Following Skinner, behavior acquired under these arrangements may characterized as superstitious.

In the classic experiment on superstitious conditioning (Skinner, 1948), the rule of reinforcement was entirely unconditional. The delivery of food was governed only by a temporal schedule and was therefore without regard to behavior. Since food was delivered in an unchanging environment, it can be regarded as unconditional with respect to stimuli, although holding the stimulus constant yields a special case of unconditionality. It would more closely parallel the sense in which food delivery is unconditional on behavior had a stimulus been switched between two or more values independently of food delivery. In any case, the well known result of Skinner's experiment was the development of stereotyped, although idiosyncratic, movement patterns.

An arrangement of the second type, in which reinforcement is conditional on responses but unconditional on stimuli, was investigated by Morse and Skinner (1957). The pigeon's key-peck was reinforced at variable intervals (reinforcement conditional on responses). Once during each hour the color of the key was changed for a 4-min period independently of the program of reinforcement (reinforcement unconditional on stimuli). Some birds developed an especially high rate during the 4-min stimulus while others developed an especially low rate. The direction of change in rate reversed for some birds in the course of long exposure to the procedure. Although the key-peck was conditioned before the stimulus changes were introduced in the Morse and Skinner experiment, that is not an essential feature of the second type of superstitious conditioning. Had a response with an appreciable operant level been chosen, the strengthening of the response through conditional reinforcement, and the acquisition of control by stimuli programmed independently of reinforcement, might have proceeded together. The essential feature of an arrangement of the second type is independence of the program of stimulus changes from the program of rein-

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forcement, coupled with the dependence of reinforcement on responses.

An arrangement of the third type, in which reinforcement is conditional on stimulus values but not on responses, was used in the present experiment. A standard pigeon key was lighted just before food was delivered. The repeated pairing of light with food conditioned a variety of movements to the lighted key. Among these movements was a peck at the lighted key. Because the key-peck is normally shaped by the use of response conditional reinforcement, its emergence under the present circumstances is especially interesting. We have therefore concentrated on analyzing the conditions responsible for the emergence of the first key-peck rather than on other movements that develop in the presence of the stimulus that precedes reinforcement.

Types of superstitious conditioning are classified in terms of procedures, not in terms of behavioral outcomes. The classification does not imply that the behavioral effects observed in each case arise from the same conditioning process. To say that all three procedures produce superstitious conditioning points only to their common feature; namely, that they entail certain unconditional relations among stimuli, responses, and reinforcements. The present experiments show that the emergence of the key-peck when a key-light is repeatedly paired with food presentation is the result of a conditioning process of some sort. Critical questions remain, however, as to what kind of conditioning is at work.

METHOD

The following features were common to the several experiments.

Subjects

Experimentally naive male White King pigeons, 5 to 6 yr old upon arrival in the laboratory, were maintained at 80% of their free-feeding weight.

Apparatus

A single-key operant conditioning box for pigeons (Lehigh Valley Electronics Model 1519C) was used. The center of the translucent plastic disc that served as the key was located in the center of the working panel 10 in. above the floor. The center of the opening to the food tray was located 5 in. directly below the key. Reinforcement was 4-sec access to the grain tray. The general illumination of the box, backlighting of the key, and lighting of the food-tray opening during reinforcement were provided by supplying 25 v ac to miniature lamps (No. 1820). The compartment light was mounted in a housing, above the key, which directed the light toward the ceiling. It remained on throughout all sessions. A steady masking noise was used in the box. Automatic programming and recording equipment was located in a separate room.

Recording

The basic datum was the occurrence of the first key-peck. An Esterline-Angus operations recorder provided a continuous record of stimulus presentations and responses.

Pretraining

Subjects were trained to approach quickly and to eat from the lighted food tray. Initially the tray was held in the up position and the food-tray opening was filled to the brim with grain. After the pigeon had eaten for 10 to 15 sec, the tray was lowered. On subsequent presentations, the tray was held until the pigeon ate from it. By the end of 10 tray operations all pigeons were reaching the tray and eating within a 4-sec tray-up interval. The key was unlighted during this phase. The tray was raised without knowledge of the bird's position.

EXPERIMENT 1

The basic paradigm consisted of the repeated pairing of a stimulus with the delivery of food. If the emergence of a key-peck under this regime were the result of some form of conditioning, the order in which stimulus and food appeared should be critical. In Exp. 1 the results of forward pairings (stimulus then food) were compared with the result of reverse pairings (food then stimulus).

Procedure

Forward pairing. Thirty-six subjects received two sessions, each consisting of 80 pairings of an 8-sec white key-light followed immediately, at the offset of the key-light, by a 4-sec tray operation. Between trials the key was unlighted. The intertrial intervals varied

randomly from 30 to 90 sec in 5-sec steps. All values were equally represented, yielding a mean intertrial duration of 60 sec. Two other conditions that had no effect on the emergence of the *first* key peck were introduced to maintain the peck to the lighted key for use in subsequent experiments. A peck during the 8-sec light-on period turned the light off and operated the tray immediately. A peck in an intertrial period prevented the appearance of a trial for the next 60 sec.

Reverse pairing. Twelve subjects received the same treatment except that the order of tray operation and key-light was reversed. The tray operated for 4 sec and then the key-light came on for 8 sec. As in the forward pairing case, although irrelevant to the emergence of the first key-peck, a response on the trial turned the light off and operated the tray.

Results

A schema of the experimental arrangements and summary results are shown for the two groups of Exp. 1 and for those in subsequent experiments in Table 1.

All 36 subjects in the forward-pairing group made a key-peck during the 8-sec trial at some point within the series of 160 trials. The mean and the range of the trial number of first peck are given in Table 1. For all but one subject, the first peck was made during the trial. An average of only 3.8 intertrial responses were made per session. Discriminative control by the key-light was unmistakable.

Direct observation and a study of motion pictures made of pigeons that were not part of the present group showed the following gross stages in the emergence of the key-peck: first, a general increase of activity, particularly during the trial-on period; second, a progressive centering of movements around the area of the key when lighted; and, finally, pecking movements in the direction of the key. As would be expected, the conditioning of recognizable movement patterns to the light occurred well before the key-peck. In almost all cases it became evident after 10 to 20 pairings that the lighted key occasioned specific movements, oriented to the key, that did not appear in the intertrial interval.

In the reverse-pairing condition only two of the 12 subjects struck the key within 160 trials; far less activity was directed toward the key. After two sessions, the 10 pigeons which failed to peck under the reverse-pairing procedure were placed on the forward-pairing procedure. Eight acquired the key-peck within an average of 59 trials (range of 13 to 88 pairings). The remaining two showed clear conditioning of some form of response occasioned by the lighted key but did not peck within a total of 160 forward-pairings.

EXPERIMENT 2

The results of the previous experiment demonstrate the importance of the order of the pairings. It is possible, however, that the comparison of the two orders exaggerates the efficacy of the forward-pairing arrangement because the reverse-pairing may work against the occurrence of movements toward the lighted key (*cf.* Rescorla, 1967). A group of subjects was therefore run with trial presentations but no tray operations in order to estimate the operant level of response to brief key-lights. There is also a practical question. If one is simply interested in conditioning a key-peck, is it helpful to use a momentary illumination of the key in conjunction with tray operations or would steady illumination of the key do as well in producing the first peck? To answer that question, a group was run with a steady key-light and intermittent tray operations.

Procedure

Trials only. Six subjects received a program identical to that in the forward-pairing condition of Exp. 1 except that the tray did not operate.

Tray operation only. Twelve subjects received tray operations on the same schedule as in the forward-pairing condition of Exp. 1. The key-light, however, remained on throughout the sessions.

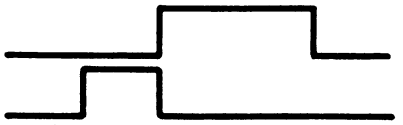
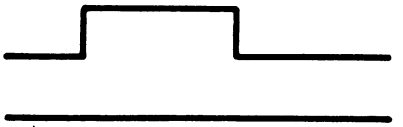
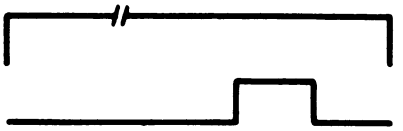
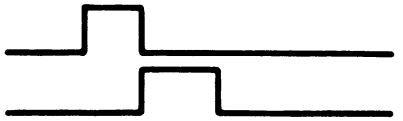
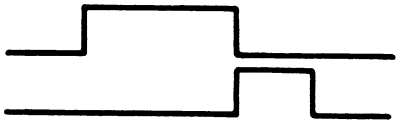
Results

From the summary data for these conditions in Table 1, it can be seen that no animal pecked the lighted key under the trials-only condition. All were subsequently placed on the forward-pairing procedure and all acquired the key-peck within an average of 23 trials and a range of 6 to 45 trials.

The time available to make a peck at the constantly lighted key in the tray-only condition was about seven times longer than in

TABLE 1

SUMMARY OF RESULTS

0 2 4 6 8 seconds PROCEDURE	NUMBER OF Ss	NO. & % OF Ss EMITTING A PECK WITHIN 160 TRIALS	MEAN TRIAL OF 1st PECK	RANGE
 (FORWARD PAIRING)	36	36-100%	45	6-119
 (REVERSE PAIRING)	12	2-17%	54	50-57
 (TRIALS ONLY)	6	0-0%	—	—
 (TRAY ONLY-CONSTANT LIGHT)	12	4-33%	NOT APPLICABLE	
 (FORWARD PAIRING-3 SEC. TRIAL)	22	21-95%	47	10-112
 (FORWARD PAIRING-DARK KEY)	6	2-33%	141	140-142
 (FORWARD PAIRING-RED KEY)	6	6-100%	33	14-66
 (FORWARD PAIRING-FIXED TRIAL)	12	11-92%	55	26-133

the forward-pairing condition, but only four of the 12 subjects in the tray-only condition made a peck at any time. This proportion is very significantly less than the 36 of 36 animals that made a first peck in the forward-pairing procedure. The tray-only procedure did produce superstitious movement patterns of the kind described by Skinner (1948) but the movements were not as a rule oriented to the key.

The results attest to the efficacy of the forward-pairing procedure and show it to be superior to the use of a constantly lighted key with intermittent food presentations for the practical purpose of establishing a key-peck.

EXPERIMENT 3

The effects of three variations of the key-light stimulus were examined in the forward-pairing procedure.

If orienting toward and looking at the key is concentrated at the onset of the light, a shorter time between onset and food delivery might produce more rapid acquisition of the peck. A group was therefore run with a shorter trial stimulus.

The similarity of the white-lighted food-tray opening, in which the bird pecks at grain, to the white-lighted key might contribute to the occurrence of the key-peck through stimulus generalization. It should be noted, however, that the presumed effect of stimulus generalization would apply equally to the forward-pairing and to the reverse-pairing condition. Conceivably, however, similarity and forward-pairing interact to produce the result in the forward-pairing condition. The similarity of the trial stimulus to the tray light was reduced in different ways in two separate groups in order to examine the contribution of stimulus generalization.

Procedure

Forward pairing—3-sec trial. Twenty-two subjects were trained under the forward-pairing procedure with a 3-sec trial rather than the 8-sec trial used in the previous forward-pairing groups.

Forward pairing—dark key. Six subjects received the standard forward-pairing program except that the key was lighted (white) during the intertrial period and was turned off on the 8-sec trial that preceded tray operation.

Forward pairing—red key. Six subjects received the same program as the previous group except that the key changed from white, during the intertrial period, to red on the trial, rather than from white to off.

Results

Results for the group that received forward pairings with a 3-sec trial are shown in Table 1. All but one of the 22 subjects pecked the key. However, acquisition was not faster than with the 8-sec trial. The shorter trial does reduce the opportunity for the peck to occur and this may balance out the advantage, if any, of a shorter interval from trial onset to reinforcement.

When the key-light was turned off on the trial (forward-pairing–dark-key condition in Table 1) two of the six subjects made a peck on the trial, and in both cases this occurred late in the second session. An additional two sessions were carried out. Two more birds pecked the dark key, one on the 195th pairing, the other on the 249th pairing. In all four cases, the first peck was made on the trial.

Direct observation showed that a special movement was conditioned on the dark-key trial, but the key-peck was clearly less likely to emerge, or at least required more pairings, in this arrangement than when the trial was marked by the lighting of the key. It is perhaps remarkable that the dark key was pecked at all, since during the trial the key had the same general appearance as the remainder of the panel. In the dim illumination of the enclosure there was little to contrast the key with the background.

The use of a red key on the trial made it stand out from the background on the trial, but still made the trial stimulus dissimilar to the white-lighted tray opening. All six subjects in the forward-pairing–red-key group acquired the peck. In every case the first peck occurred during the trial period. Subsequently an average of 41 intertrial responses per session occurred, a higher rate than was found with the standard forward-pairing arrangement (Exp. 1). The increase in intertrial responding is probably the result of greater generalization between a red trial stimulus and the white intertrial stimulus than is found with a white trial stimulus and a dark key between trials. The important point to note, however, is that the first peck occurred to the

red key, not to the white intertrial stimulus which was more similar to the tray light. Further, acquisition with red key-light was no less rapid (average of 33 trials) than with a white key-light. Stimulus generalization from the tray-light to the key-light does not appear to contribute significantly to the present result.

EXPERIMENT 4

In the previous experiments the first key-peck brought an immediate operation of the food tray. Consequently the routine maintenance of responding after the first peck was not of special interest. In the present experiment key-pecks did not affect the trial duration nor the operation of the tray. It is of interest to examine the course of responding beyond the first peck for this arrangement.

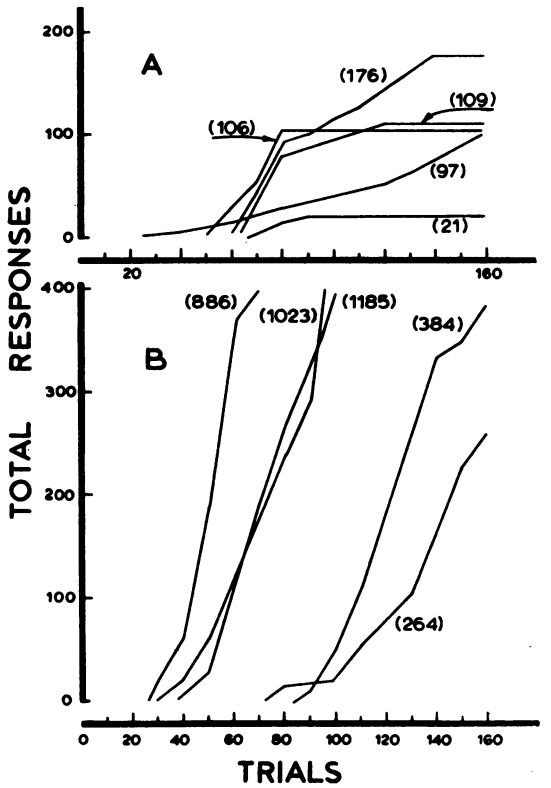


Fig. 1. Cumulative responses for individual birds in Exp. 4 in which a key-peck did not terminate the trial. Numbers in parentheses indicate total key-pecks by the 160th trial. For purposes of presentation the five subjects with a low rate of responding are shown in Panel A and the five with a high rate of responding are shown in Panel B.

Procedure

Forward pairing—fixed trial. Twelve subjects received the standard forward-pairing procedure with an 8-sec trial which now remained fixed in duration throughout 160 pairings in two sessions.

Results

As shown in Table 1, all but one of the 12 subjects made at least one key-peck. One pigeon made only a single key-peck. Cumulative response curves for the remaining 10 birds are shown in Fig. 1. Five subjects developed and maintained a high rate throughout the 8-sec trial. The others showed an appreciably lower level of responding and several stopped pecking the key before the end of the second session. One animal continued pecking during the trial but the location of the peck drifted away from the key. As would be expected, the arrangement does not guarantee a stable performance, but it is capable of generating a surprisingly high level of maintained key-pecking in a substantial percentage of cases. Again, intertrial key responses were infrequent (mean of 5.8 per session for the 11 subjects represented in Fig. 1).

In terms of the appearance of the first key-peck, the results for the fixed-trial group were similar to those obtained in the standard forward-pairing condition and in the forward-pairing–3-sec trial condition.

COLLECTED RESULTS FOR ACQUISITION

A frequency distribution of trial number on which the first peck occurred is shown in Fig. 2 for the 70 pigeons run under the three forward-pairing–3-sec trial group in Exp. 3 and the forward-pairing—fixed-trial group in Exp. 4. The mode of the distribution lies between the 21st and the 40th pairings.

DISCUSSION

The experiments have shown the reliable emergence of a key-peck as the result of unconditional forward pairings of a key-light stimulus and food. Some of the conditions for the occurrence of this response have been explored, but the present arrangement con-

tains other features whose contribution to the result is unknown. Experiments in progress show that the location of the key near the food tray is not a critical feature, although it no doubt hastens the process. Several birds have acquired the peck to a key located on the wall opposite the tray opening or on a side wall. On the other hand, the use of a key-light as a stimulus is undoubtedly a critical feature. It could hardly be expected that an auditory stimulus or variations in overall illumination would yield a key-peck with the present procedure. For reasons shortly to be discussed, a question of particular interest is whether the use of grain as a reinforcer is essential to the emergence of the peck.

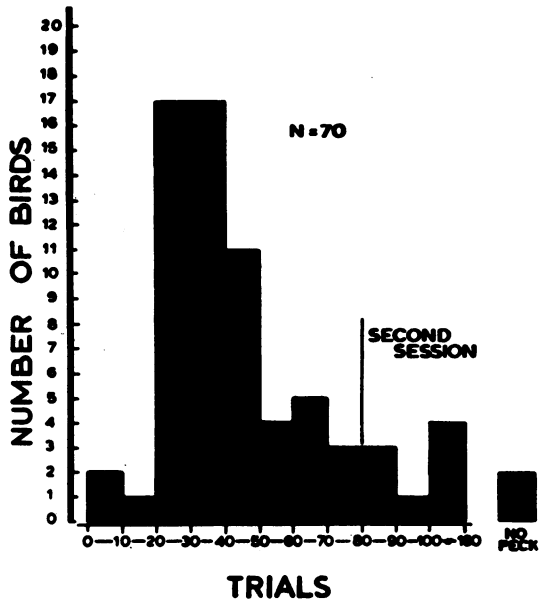


Fig. 2. Frequency distribution showing trials on which birds in certain forward-pairing groups (see text) emitted the first peck.

In our present view, the emergence of the key-peck may be characterized as a process of auto-shaping on which a direction is imposed by the species-specific tendency of the pigeon to peck at the things it looks at. The bird notices the onset of the light and perhaps makes some minimal motor adjustment to it. The temporal conjunction of reinforcement with noticing leads to orienting and looking toward the key. The species-specific look-peck coupling eventually yields a peck to the trial stimulus.

An appeal to some species-specific predispositions with respect to the stimulus is made necessary by the progressive change in behavior that leads up to the peck. It is not the initial behavior to the lighted key that is established by reinforcement. The progression would appear to be toward more rather than less effortful forms.

With the exception of the species-specific component, our account essentially parallels the accounts offered by Skinner (1948) and by Skinner and Morse (1957) for the first and second types of superstitious behavior. It relies on the shaping action of reinforcement and on the acquisition of discriminative control over the shaped response as a result of the joint presence of the stimulus and the reinforced response. However, what we have called a third type of superstition is also the standard arrangement for classical conditioning and that suggests the possibility of classically conditioned effects arising directly from the repeated pairing of a stimulus with food. Although we agree completely with Kimble's comment (1964) on a paper by Longo, Klempay, and Bitterman (1964) that the use of a classical conditioning procedure in no way guarantees that any response that becomes conditioned is a classically conditioned response, we nevertheless think it unwise to ignore the possibility that some form of classical conditioning contributes to the result.

There are two ways in which this might occur. First, classical conditioning could produce the response through stimulus substitution. The CS (lighted key) comes to evoke the response (peck) elicited by the UCS (grain). That seems unlikely because the peck appears to grow out of and depend upon the development of other motor responses in the vicinity of the key that do not themselves resemble a peck at grain. Even so, it will be of interest to see whether the use of water as a reinforcer, at which birds do not peck, will also condition the key peck.

Second, there is now a considerable number of experiments showing that classical pairings of a stimulus with food make the stimulus capable of affecting operant responses that were not occurring and could not have been shaped or specifically reinforced during the pairings (Bower and Grusec, 1964; Bower and Kaufman, 1963; Estes, 1943; Estes, 1948; Morse and Skinner, 1958; Trapold and Fair-

lie, 1965; Trapold and Odom, 1965; Walker, 1942). Clearly, there are stimulus effects resulting from pairing that are not specific to whatever responses may be concurrent with the pairing. Would not the same type of effect be involved in the acquisition of responses that are being made concurrently with the pairings as in the present arrangement? A general excitatory effect of the key-light resulting from the pairing of light and food may facilitate the general activity out of which the shaping produces a particular form of movement. While it is hard to see how an effect of this sort could not be involved, untangling a classical component from the response-specific action of reinforcement is extremely difficult, as the literature on the distinction between classical and operant conditioning so amply demonstrates.

Although the emergence of the key-peck as the result of response-independent pairings of the key-light with food raises several as yet unanswered questions about underlying processes, it does produce the key-peck with surprising regularity. When a large number of birds is to be used, the procedure saves time and labor. It no doubt results in idiosyncratic movement patterns associated with the peck itself, but is probably no worse in this respect than is hand-shaping. The procedure is easier to specify and to standardize. Further, it is free from the systematic effects that might be expected to result from individual differences among experimenters in the art of hand-shaping.

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